CRUSHER

The invention relates to a crusher or breaker for bulk material in a heterogeneous mixture, enabling the reduction of this material to particles of small sizes so as to reduce the volume thereof as far as possible. Its operation employs a system of toothed blades in relative linear motion, combining simultaneously shearing functions with breaking functions. If the material in question is essentially organic and non-infectious, it will be possible to use the crushed material obtained as compost, whereas if the opposite is the case, it will be possible to dump it directly. Sorting or other processing thereof, such as decontamination or sterilisation, will thereby be facilitated.

For a long time there has been a need to crush used materials, and numerous methods and devices have been developed for the crushing of such materials, enabling the crushing, cutting, chopping, tearing to pieces, dilaceration, etc. thereof.

In reality, only a small number of methods are in current use. They employ knives or shears, such as paper crushers, rotary-blade crushers, for the destruction of metals, plastics and rubber, or else jaw crushers (stone or rock materials). Each of these methods has often prohibitive disadvantages when they are used outside their strict applications, for example for processing heterogeneous mixtures of diverse materials.

Nowadays, the increase in the costs of transporting and storing waste makes it necessary to crush the materials at a location as close as possible to the place where they are produced. There is thus a great and ever-increasing demand for a used-material crusher which takes up little space, is lightweight and is usable, for example, in a workshop or laboratory, and even simply as a domestic appliance. This type of apparatus must have low consumption, make little noise and be able to process various materials of greatly varying thicknesses. As already indicated, the known solutions mentioned above have

little to offer in this regard. Paper crushers are not strong enough to process plastic and metals, even of low thickness. Crushers of larger dimensions generally operate with the aid of rotary blades which generate a noise which necessitates protection in order to be able to stay in the vicinity. The problem of the crushing of fabrics and quarry waste also remains. Crushers or breakers used in quarries, apart from the enormous noise which they too generate, are of dimensions which are too large, consume enormous amounts of power, and produce excess fines and dust.

As a matter of interest, mention will be made of crushers of the type having balls or hammers, used in laboratories or in industry for reducing hard materials to fine powders, but these instruments generate intolerable noise and in any case are not designed for processing materials consisting of heterogeneous mixtures.

In contrast, the invention solves the above-mentioned problems, namely to obtain a particulate product which can be easily handled, processed further if necessary, transported and stored.

The crusher according to the invention enables the reduction to particles of heterogeneous materials, both organic and mineral or mixed: it is of small dimensions, is quiet and consumes little power, merely using a conventional electrical connection, as can be found in a simple residence. Furthermore, it will be seen that it is self-cleaning and that its actual design enables very easy maintenance.

A feature of the crusher is that its operation combines a crushing action which cooperates with a double shearing action in two orthogonal spatial planes.

Preferably, the orthogonal planes are vertical and horizontal planes.

According to one embodiment, the crusher comprises at least two successive pairs of movable toothed blades forming jaws, each pair consisting of two opposite corresponding toothed blades driven in a reciprocating

motion moving them apart and bringing them together so as to come into abutment against one another when the teeth are engaged in one another, the second pair of blades sliding against the first pair of blades and coming into abutment in a position offset with respect to the abutment position of the first pair of toothed blades.

The blades advantageously possess a curved, for example S-shaped, profile, to avoid the possibility of long thin pieces passing through the blades without being cut.

Preferably then, the blades constituting the pairs of blades are in a vertical position and possess serrations having horizontal surfaces oriented respectively upwards and downwards, so that the shearing actions are respectively vertical and horizontal.

In an advantageous embodiment, the blades extend upwards by way of upper zones, which are likewise toothed, but which do not engage in one another and adopt in contrast a V-shaped geometric position when the toothed blades are in abutment against one another in the crushing zone.

In another embodiment, the crusher comprises in the lower part a cutout forming a free space in which the teeth do not come into abutment. As a variant, the crusher comprises another cutout which cooperates with a nose or nib projecting concordantly on the opposite blade.

The shape of the blades and their thickness, as well as the material used, will be chosen in accordance with the products to be crushed and the size of the crushed product desired, as will be specified further on.

By means of this feature, the materials are pushed downwards into the crushing zone. Such a crusher is self-feeding.

It is, however, possible to provide additional means for pushing the materials towards the blades, for example for the processing of waste which is lightweight and has a large empty volume, such as empty plastic bottles.

In the crushing zone, the toothed blades constituting the pairs are advantageously arranged obliquely.

The pairs of blades may be driven with respect to one another in a synchronous or an asynchronous motion, and between the movable blades may be interposed blades which are fixed or have a different stroke.

The blades may be brought together and moved apart on a linear path situated on a congruent axis, in the same plane, or in two planes forming between them an obtuse angle other than 180°, for example up to 120°. The converging motion in this case is oblique, preferably downwards in order to further intensify the self-feeding phenomenon of the waste.

It should also be noted that this reciprocating motion, whatever the planes, may also be curvilinear or arcuate, here too oriented downwards when the blades are brought together. Such a result is easily obtained by offsetting the axis on which the blades are fixed, with respect to the point at which the actual reciprocating motion is applied to them. This generates a swinging motion, downwards if the point at which the blades are fixed is at the bottom.

Owing to its actual design, such a crusher may be in modular form, it being possible to add pairs of toothed blades alongside existing blades to increase the crushing capacity, or remove them to reduce the capacity, weight and space taken up. This is obviously a great advantage compared with traditional crushers, in particular compared with worm crushers, which are naturally fixed in their dimensions and capacities.

Of course, apart from the above elements which constitute the actual invention, the crusher also comprises mechanical parts necessary for its operation, that is to say one or more motors powered electrically or pneumatically or else hydraulically, the necessary frames or supports, the feed hoppers and the members for discharging and recovering the crushed materials produced.

Also, of course, the blades are made of a material which is strong enough to cut and crush, while retaining a residual elasticity to allow for the shearing forces. The material chosen for the blades or their coating, as well as the shape and design of the teeth and mechanical interfaces, depends on the chosen applications. Mention will be made of steel, carbides or nitrides, certain ceramics obtained by sintering in particular, in solid or plated form.

It should be understood that when "abutment" is referred to, this does not necessarily mean that the teeth come directly into contact face against face: the abutment motion may leave a slight space remaining between these two blades, which is precisely of the order of magnitude of the sizes of the particles of crushed materials obtained. In addition, to allow a mechanical tolerance, the teeth in the abutment zone may possess a slight cutout at the end or chamfer.

Although the crusher according to the invention requires at least one pair of blades to function, it is obvious that, in practice, the number of blades will be much higher, typically from a few tens to a few hundreds, without this number necessarily being even. Everything will obviously depend on the crushing capacity required and on the general dimensional constraints.

The width of the blades also depends on the sizes of the particles of the crushed material, as well as on the maximum sizes of the materials to be crushed, the number of blades placed side by side defining the maximum length of the material accepted.

The invention will be better understood with reference to the attached drawings, given by way of non-limiting example. In these drawings:

- Figure 1 is a side view of the pair of cooperating blades driven in a reciprocating motion bringing them together and moving them apart;

- Figure 2a is a view of a pair of identical blades, shown in perspective, but the upper part of which is funnel-shaped;

- Figure 2b is a perspective view corresponding to Figure 2a, in which several pairs of blades are arranged side by side;

- Figure 3 is a plan view of the basic arrangement explaining the interpenetration of the blades and the shearing actions; and

- Figure 4 is a view similar to that of Figure 1 and relates to another embodiment.

As can be seen in Figure 1, the pair of blades comprises a blade 1 or "male" blade, and a blade 2 or "female" blade cooperating with the blade 1. Each of these blades comprises perforations 3,4 serving respectively to fix them on supporting and driving shafts (not shown), 5,6 respectively, the aim of which is above all to lighten the weight of the assembly. The male blade 1 comprises an upper entry zone 7 which serves to compact, pre-crush, possibly pre-grind and pre-tear, the material brought into this zone, and a lower zone 8, where the crushing and final grinding is carried out. The female blade 2 likewise comprises an upper zone 9 and a lower grinding zone 10, the teeth of which interpenetrate and cooperate with the teeth of the zone 8. The two upper zones 7,9 of the blades together form a V-shaped hopper, the role of which is to advance the material held in this hopper downwards.

In the lower zone, the male blade 1 projects, whereas the corresponding part of the female blade 2 is S-shaped, so as to define a passage for the crushed material and avoid the possibility of pieces passing through the blades without being processed.

These teeth are designated by the reference numerals 11,12 on each of the two blades, male 1 and female 2 respectively. In their upper zones 7,9, the blades 11 have teeth which possess a horizontal face 13 directed upwards. Given that the other face 13' of these same teeth 11 is

inclined downwards, the moving apart and then the bringing together of the blades pushes the material downwards, as indicated above, creating a self-feeding action.

In the lower zones of the blades, which are advantageously inclined with respect to the vertical (by an angle α of about 45° in the figures, but which may for example be between 0 and 60°, values which may vary enormously depending on the applications), the teeth possess respectively a horizontal face oriented downwards 14 and a horizontal face oriented upwards 15.

Although not shown in Figure 1, for the sake of simplicity, the blades possess a slight cutout at the end in order to facilitate their fitting together, while allowing a mechanical tolerance in the mounting of the systems of blades. However, such a cutout or chamfer is shown on a blade of Figure 4, reference 16.

Finally, between the upper zones 7 or 9 and lower zones 8 or 10 of each blade 1 or 2, there is a connecting zone comprising more conventional teeth 12 with inclined faces, these faces being complementary so as to fit together.

These blades are driven in a reciprocating motion bringing them together in accordance with f1 or moving them apart in accordance with f2. When they are brought together f1, all the teeth of the intermediate connecting zones and of the lower zones fit together, the faces 14 and 15 of the teeth in correspondence sliding against one another while exerting a horizontal shearing action.

It should be noted that with the words "horizontal" and "vertical", the point of reference is the axis of the crusher as a whole, as it is normally installed, placed or fixed on the ground. It may be inclined, without this in any way changing the crushing and shearing actions.

In Figure 1, the upper zones of the two blades form a figure in the shape of an upright V, forming a feed hopper, with a half opening angle of the order of 45° with respect to the vertical. This angle ß, which may be identical to or

different from the angle α mentioned above, may also vary between 0° and 60°, and the V may possess a profile which is curvilinear or in successive sections of different inclination. This part thus forms a funnel for the material to be crushed and the shape of the teeth present in the funnel helps to move the material downwards towards the lower grinding zone, as has already been indicated and is clearly apparent in Figure 2a.

In this Figure 2a, which is merely a simplified diagram showing only a single pair of blades, the movement of the material downwards is illustrated by the arrow f3. It will be observed that here the funnel has a shape which is not straight but curves progressively.

In Figure 2b, which corresponds to Figure 2a, the crusher according to the invention is equipped with five consecutive pairs of blades (101,201;102,202;103,203; 104,204;105,205), some of which (201,102,203,104,205) are fixed.

To be more specific, when it is desired to obtain a crusher with a particle size of the crushed materials obtained of the order of 5 mm, the following will be chosen: a blade thickness of the same order of magnitude (for example 3 to 5 mm), a height for the lower teeth of from about 5 to 10 mm, and a height of the blades in the lower zone of 6 to 8 cm, for a total height of the blades which may reach 20 cm; sixty blades, for example, will be arranged side by side for a width of 30 cm.

The value of 5 mm is merely an example, since by varying the above parameters, it is possible to choose the particle sizes of the crushed materials.

In this Figure 2b, the blade 101 is female and the blade 201 is male, the blade 102 is male and the blade 202 is female and so on alternately, the zones 1 and 9, and 8 and 10, respectively, alternating correlatively on each of the two sides.

The crusher operates in the following manner, it being understood that the motion of the blades may be

synchronised, or else offset in space or time. For greater simplicity and better comprehension, the synchronised operating mode will be explained hereinbelow in more detail. The blades move in a way that they are brought together and moved apart and the material placed in the hopper-forming "funnel" is, as far as the coarse pieces are concerned, already torn and pierced, so that first of all a compacting and partial crushing action takes place. By virtue of the shape of the teeth, the material is pushed downwards where it is compacted more and more.

There then begins a vertical shearing action as a result of the two consecutive blades sliding on one another (101 against 202; 202 against 103; 103 against 204, etc.). The material then enters the connecting zone, and then the lower zone of the blades (8,10) where it is crushed, ground, broken, cut and sheared, in short cut up and reduced to small particles. There is always a vertical shearing action between two consecutive blades, but there is then added to this a horizontal shearing action between the complementary faces, oriented respectively upwards (15) and downwards (14), of the teeth of the two opposite blades being brought together. To this double shearing action is also added a crushing action between these same two blades being brought together, forming jaws or pincers.

It will be noted that, between Figure 1 and Figure 2a or 2b, the faces of the teeth (14,15) of the blades in their lower zone have been reversed on the male and female blades. This is done to show clearly that the relative arrangement of these faces is immaterial, provided that they are horizontal.

The shearing action between two consecutive blades sliding against one another is a vertical shearing action which cuts the material, whereas the shearing action between two horizontal tooth faces in the grinding zone is a horizontal shearing action which likewise cuts the material. The crushing action is obtained by the blades

which are brought together so as to bear against one another in the lower zone 8.

The angle parameters of the funnel and its shape, and the geometry and length of the lower grinding zone are determined to enable preliminary piercing, tearing or compressing of the material in the funnel, and to enable it to be pushed into the grinding zone where it is ground when the teeth engage in one another until they are in abutment, with the clearance governed by the final size of the particles of crushed material.

Furthermore, the blades may be mounted on an elastic device (springs or dampers) with play, so that they only come completely into abutment, face against face, when there is no particle of crushed material held between them, allowing the clearance which is necessary if the opposite is the case.

Figure 3 is a plan view of the blades in a variant in which the crusher comprises alternately fixed blades (102,201,103,204,etc.), represented by shading, whereas the movable blades (101,202,103,204,etc.) are represented with hatching. The letters a, b, c and d represent different stages of the moving apart and bringing together of the movable blades. At a, all the blades are separated. At b, the movable blades have passed the fixed blades and have thus removed any material which may have become attached to them (cleaning stage). At c, the movable blades have just passed one another and the material has been cut by shearing on the vertical edges. At d, the movable blades penetrate into the fixed blades and the material is sheared horizontally by the horizontal tooth faces sliding on one another, and then crushed and ground at the end of the stroke. At this point, the movable blades are moved apart, and position a is assumed again.

It will be observed here that the friction generated when the blades are moved apart frees the material or the particles held between them, which fall downwards to be taken up by the teeth situated below. This geometry means

that the crusher according to the invention is "anti-blocking", that is to say that no particle of crushed material can accumulate over a long time until it blocks the operation of the blades.

It will also be noted, in relation to the foregoing, that the crusher is "self-cleaning" as well, the blades being arranged such that, during their travel, the vertical edge of a blade passes against the vertical edge of its neighbours. By moving forwards, a blade pushes back the material which may adhere to a tooth of its neighbours. The cut pieces fall further down to be subjected to a new crushing and shearing action.

In Figure 4, which illustrates another embodiment, the male blade 1 and female blade 2 have been crossed over from left to right, so as to show clearly that the arrangement of these blades, from right to left or from left to right, is immaterial. All the elements already described in Figure 1 are found again, with the same reference numerals.

The differences lie in the following elements. First of all, the general S shape is less marked, or even absent. The surfaces 13 and 13' of the teeth 11 in the upper zones 7 and 9 are oblique and the passages 4 and 6 are joined. It should be noted that a chamfer 16 is shown on one of the blades, but in reality, all the blades which are to slide on one another possess such a chamfer. These chamfers are aimed at improving the guidance during the inter-penetration.

The essential difference lies in the lower part of the blades, since the female blade 2 possesses, from bottom to top, a cutout 17 without teeth and with a substantially curvilinear geometry 17. According to a variant embodiment, there follows at the extremity a second cutout 20 forming a clearance. The female blade 1 in this case possesses, at the end, a projection 10 in the form of a nib or nose which will take up a position in the above cutout 20.

Between the cutout 17 and the teeth of the opposite blade is formed a free space 18 in which the materials

being dilacerated reside temporarily, before being expelled therefrom as a result of the cooperation between the nose 19 and the cutout 20.

The cutout 20 may be carried by the same blade as the cutout 17, or by the opposite blade.

It has been found that this embodiment further improves the expulsion of the crushed materials, avoiding a situation where certain filiform dilacerated materials remain jammed between the consecutive blades. It should be born in mind that the two blades being brought together and moved apart are preceded and followed by other pairs of blades being brought together and moved apart, or, as indicated hereinabove, alternately fixed blades, so that the space 18 is in reality a three-dimensional chamber.

The blades are actuated by the shafts which pass through them (see Figures 1 and 4). It should be noted here that, depending on the weight of the blades constituting the jaws and the material constituting the teeth, the driving motion must be sufficient. However, once the motion is initiated, with the blades being advantageously accelerated over a length of about 30 mm in about one second, the material is cut not only by the force imparted to the blades by the driving motion, but also by the stored kinetic energy. For example, 60 pairs of blades with a thickness of 5 mm as shown in Figure 1, actuated by 4 jacks with a diameter of 25 mm powered by a hydraulic unit with a 0.75 kW motor, provide a torque of greater than 1 tonne.

Owing to its remarkable efficiency due to the triple action, shearing in two planes and crushing, the crusher according to the invention may be of small dimensions and of low weight and thus have wide application in fields where it is necessary to have a crusher which is lightweight and consumes little power, for reducing heterogeneous materials, such as waste, to particles as small as possible and for reducing the volume thereof.

Such a crusher will thus be advantageously usable in small workshops or laboratories or in the home, as well as

on board aircraft where weight and bulk pose major problems and where in general only metered electricity generation is available.

Furthermore, this crusher may constitute one of the elements of a multi-stage crushing assembly, comprising a plurality (n) of crushers according to the invention installed in series. The crushed material obtained by one crusher (n-1) feeds the following crusher (n) in the series.

The crusher or crushing assembly will also be of special interest in the hospital environment. The reason for this is that hospital waste is in general a mixture of human tissues, diverse textile materials (compresses, etc.), rubber materials (surgical gloves, etc.), syringes (mixture of plastic and metal), and even paper and cardboard (packaging). Because human tissues are liable to be infectious, hospital waste must not be fed into the traditional system. On the contrary, it must be processed separately, either in ad hoc plants outside the hospital, or in a treatment centre inside the hospital. These are always huge, noisy installations with a very high power consumption, with which are associated sterilising installations for destroying all the pathogenic germs. In all cases, the waste must be transported outside the operating theatre.

Recently, medical processing apparatuses using microwave sterilisation have been developed, comprising a crusher for the pre-processing of the waste, of sufficiently modest dimensions so that each operating theatre or each department can have its own apparatus, thereby avoiding any transportation and outside handling. Such a microwave processing apparatus is described for example in WO 97/44069.

In order for the apparatus in question to retain a bulk compatible with the operating theatre, it is necessary for the hospital waste which is to be processed, of a heterogeneous nature, to undergo preliminary crushing to

small sizes and this is precisely where the crusher according to the invention comes in, as an independent machine, or preferably in a combined installation for crushing and sterilising, in particular sterilising using microwaves.